# INSTITUTE AND FACULTY OF ACTUARIES

# EXAMINERS' REPORT

September 2010 examinations

## Subject ST9 — Enterprise Risk Management Specialist Technical

**Introduction**

The attached subject report has been written by the Principal Examiner with the aim of helping candidates. The questions and comments are based around Core Reading as the interpretation of the syllabus to which the examiners are working. They have however given credit for any alternative approach or interpretation which they consider to be reasonable.

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Chairman of the Board of Examiners

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**1** (i) (a) Market risk
Credit risk
Insurance risk

(b) Other categories, such as reputation, strategic, and agency risk, are unlikely to be relevant for capital assessment purposes.

(ii) A common example of a risk which can be categorised in different ways is the risk of fluctuations in the value of corporate bonds due to changes in the credit spread. Some organisations will categorise this as market risk, some as credit risk.

Another example is the risk associated with an earthquake: a general insurance company might treat this as an insurance risk, whereas a bank would treat this as an external event under operational risk.

*[Several candidates stated and gave other risks which were also accepted.]*

**2 Benefits of ERM implementation**

ERM can help an organisation to:

- Formally align its risk appetite and strategy.
- Minimise unpleasant operational surprises.
- Reduce the risk of bankruptcy.
- Protect its reputation or brand.
- Enhance its catalogue of risk response decisions.
- Ensure that it has the appropriate skills to manage all of its risks.
- Improve its organisational effectiveness, particularly the direction and use of senior management time, through co-ordination and integration.
- Improve its risk reporting through careful prioritisation of the level and content of risk information that should go to the board, thus increasing both risk transparency and reporting efficiency.
- Ensure that risks are considered holistically, across all the different types of risk in different business areas, focussing in particular on their interdependencies.
- Gain consistency within the risk management process across different companies within a group and countries of operation.
- Allow better for diversification benefits across business units / entities and therefore avoid over-hedging or excessive insurance coverage.
- Align its performance metrics with the overall business and risk objectives.
- Identify and exploit opportunities to add value from upside risks.
- Expand, through proactively taking on risks that have been thoroughly assessed and understood.
- Improve capital needs assessment and allocation.
- Reduce the costs of external financing.

ERM also:

- Improves third parties' perception of the organisation, e.g. regulators and auditors.
- Reassures shareholders and help to support the share price, e.g. by reducing earnings volatility.
- Supports the organisation's credit rating, since credit rating agencies are putting increased weight on the quality of risk management functions.
- Promotes both financial security and job security, particularly for senior managers.

*[Other points were also accepted.]*

**3** (i) (a) Stress testing measures loss under extreme values of the chosen variable without necessarily considering the probability of that extreme event.

(b) The phrase "sensitivity analysis" is often used to describe a similar test but under less extreme variations. It is used to investigate what would happen if individual assumptions shifted slightly.

(c) Scenario testing usually refers to the process of measuring the impact on the firm as a result of changes to two or more variables under devised "what if" scenarios – again without necessarily considering the probability of that scenario.

(ii) (a) and (b) together

- Insurance risk: by increasing the number of claims experienced by the firm
- Insurance risk: by increasing the claims expenses incurred by the firm
- Insurance risk: by increasing the number of lapses experienced as people seek to access cash balances / reduce outgoings (and these lapses could be selective)
- Market risk: if people stay home consumption will fall prompting falls in equity values
- Liquidity risk: a large number of claims may prompt the need to sell assets unexpectedly to cover risks
- Operational risk: a large number of staff will be off (either sick or looking after sick loved ones) reducing the ability of the firm to carry out its day-to-day functions like processing claims, monitoring investments, etc.
- Political risk: the government may be prompted to take unusual / emergency actions under the circumstances which could impact on the regulatory environment, interpretation of claims etc.
- Reputational risk: public sentiment may turn against firms applying strict underwriting or definitions of valid claims related to the pandemic illness.

- Moral hazard: Having insurance in place may make people less likely to take precautions resulting in larger numbers of affected and claims

*[Several candidates gave other risks which were also accepted.]*

(iii)

- Insurer A would start by working out how much it could afford to lose in the event of a pandemic.
- Combinations of the level of excess deaths and other pandemic impacts would then be considered
- to understand how well positioned the company is to withstand them
- and what mitigating actions (e.g. reinsurance) should potentially be considered.

**4** Whilst the ERM framework could be based on the same concepts the actual procedures, guidelines and reporting requirements must be proportionate to the two companies. Companies A and B are very different. Company A is much larger. It is a retailer. Company B is both smaller and a wholesaler.

Prior to the merger Company A might have been transferring risk to Company B. Now the ERM systems of both companies need to reflect the group position.

For ERM to be effective it must be embraced by Company B's board, management and employees. It cannot be imposed by Company A. Therefore Company A may have to adjust its ERM style in order to "sell it" to these new stakeholders.

Companies A and B will likely have different capital structures.

Companies A and B will likely have different risk appetites.

The ERM policies must be built around a company's capital and risk appetite.

The different risks which will require different procedures, guidelines and reporting include:

- Credit risk – Retailer will sell for cash or cash equivalent. Hence very little credit risk. Company B will sell on deferred terms to its customers making it very exposed to a relatively small number of corporate customers.

- Market risks – changing costs of inputs. Company A will likely have a mix of fast and slow turnover items. Company B will be predominantly very fast turnover items.

- Market risks – customers. Company B will have fewer and relatively much larger customers. Company B is more exposed to the loss of customer but can spend more time and care on each individual customer. Company A must develop mass marketing procedures.

- Technology risk – Company A is bigger and much more complex e.g. customers, premises, employees etc. The ERM must be proportionate to the risk.

- Fixed assets risks – Company A is much more dependent on its premises. Company B is more dependent on its plant and machinery and on its logistics given its fast turnaround.

- Health and safety issues and risks – Company A will be employing customer facing people in a relatively safe store environment. Company B is employing factory workers in a factory. Different people with different jobs require different ERM approaches, policies and guidelines.

The companies will have different risk mitigation and transfer options. They will wish to employ different options because of their different risks, capital and risk appetite.

**5** (i) Liquidity risk is the risk of money markets not being able to supply funding to the insurance company when required, or more broadly to the management of short term cash flow requirements.

(ii)

- It could be argued that liquidity risk could be mitigated through holding large quantities of additional capital invested in easily liquidated assets.
- However, this would not be appropriate because the additional capital will not be appropriately employed in the business resulting in underperformance relative to ones' peers.
- Other mitigating procedures should be investigated.

(iii) At the start, need to build a cashflow projection model of both liability outgo and asset proceeds.

Do this first using best estimate assumptions and then test the ability of the business to meet all claim payments to policyholders and other outgo from income and asset sales in a range of scenarios.

Relevant scenarios include those where cash inflows are decreased or cash outflows are increased as a consequence of the stress.

The insurance company sells immediate annuity business. Once a policy has been sold the policyholder has no ability to transfer or redeem the policy. Hence, the annuity business is an illiquid liability.

The insurance company backs the business using corporate bonds which are held to maturity. These corporate bonds will not be as liquid as the equivalent Gilts. However, excepting for defaults, since the corporate bonds back annuity business and should be cash flow matched there is no need to redeem these corporate bonds. Corporate bond defaults will upset the cashflow matching.

The insurance company also backs the business using equity release mortgages. The repayment date on these mortgages is not known with certainty due to uncertainty regarding the:

- actual mortality rates that will be experienced in the future, which may advance or delay the redemption cashflows;
- actual level of long term care transitions that will be experienced in the future, which may advanced or delay the redemption cashflows; and
- actual level of voluntary redemptions that will be experienced in the future, which may advanced or delay the redemption cashflows.

The cashflow projection model should be used to optimise the proportion of assets held in corporate bonds as against equity release mortgages. Holding more corporate bonds will reduce liquidity risk but may also reduce the portfolio's expected return.

If actual mortality rates are lower than expected then there will be a greater number of annuity payments – mortality risk – whilst the redemption cashflows on the equity release mortgages will be delayed leading to a mismatch. Scenarios should be investigated to ensure that the insurance company can continue to fund the outgo in such a scenario.

Inflation may also need to be investigated if any of the annuities are inflation linked.

Premium income on new annuity business may be a source of liquid assets in such circumstances, although scenarios should be investigated to ensure that the premium income is a reliable source of liquidity.

Liquidity is also required for short term "current liabilities" such as annual tax settlements, and to meet short term expenses.

Manage risks using risk transfer by way of insurance including financial risk insurance (ART)

Establish an emergency overdraft arrangement with a bank for temporary liquidity assistance

**6** (i) Systemic risk is the risk that problems at a single firm could create a chain reaction resulting in large losses or defaults at other firms.

Financial institutions have become highly inter-dependent. For example, AIG the large American Insurance Group wrote tens of billions of dollars of credit default swaps in the 2000's. If the US government had allowed AIG to fail in 2008 then many banks would have been exposed to losing tens of billions of dollars each. It was rumoured at the time that a major Wall St bank might have failed if AIG had been allowed to fail.

(ii) A strictly stationary time series is one whose statistical properties such as mean, variance, autocorrelation, etc. are all constant over time. If the fitted model is being used to forecast the future then a strictly stationary time series is both easier to fit and, all other things equal, should produce estimates with less variance.

A weakly stationary process or covariance stationarity only requires that the first and second moment do not vary with respect to time. A white noise process is covariance stationary.

(iii) A GARCH model is said to have infinite variance if the sum of its coefficients, alpha and beta, are equal to or greater than 1. This situation typically arises when a small number of outlier data points greatly influence the parameter fitting.

(iv) Infinite variance models can enter a cycle of positive feedback where volatility increases without limit. In this case the regulator would produce a number of results showing extremely high capital requirements. It is likely that the number of these results would cause the regulator to produce far more onerous stress tests resulting in the regulator requiring that the banks maintain higher levels of minimum capital.

A higher capital requirement would force some banks to raise more capital and would either hit bank ROEs or lead to higher charges or a combination of both.

(v) The regulator could stress test the individual bank's capital models using both the extreme historic events and imaginary extreme events to estimate how many extreme events the banks can withstand.

The regulator could submit the various capital models to scenario testing to see the likely change in each bank's capital from year to year in less extreme circumstances.

The regulator could seek to build one or more models based on extreme value theory (EVT). This theory focuses on the extreme outcomes (the tail) rather than all of the outcomes and may be more appropriate in this context.

The generalised extreme value (GEV) is a family of continuous probability distributions developed for EVT. The regulator could use the GEV distribution to estimate a realistic probability density function of the observed extreme events.

The regulator should run alternate GARCH models which have finite variance to understand how much of the minimum capital requirement was being driven by the infinite variance assumption; the infinite variance assumption being a consequence of fitting the extreme events to the GARCH model.

(vi)

- Limit exposure to short term funding by limiting the ratio of short term funding to the total bank funding.
- Introduce various product limits to emphasise diversity
- Increase liquidity ratios to make the banks better able to withstand short term funding difficulties and unexpected withdrawals.
- Set limits to a bank's leverage i.e. The multiple of loans to equity
- Introduce other risk mitigants for example requiring banks that find themselves in difficulties to raise capital or merge.
- Prohibit certain trading activities that are considered to be unnecessarily risky.
- Adopt more prudent valuation of liabilities/assets
- Require more frequent and more detailed reporting e.g. off balance sheet risk reporting
- Set limits on asset holdings
- Set limits on counterparty exposures
- Extend qualitative reviews/management assessments

**7** (i) (a) The aggregate operational loss distribution is as follows:

$$S = \sum_{i=1}^{k} \sum_{j=1}^{N_i} X_{ij}$$

where:

- $k$ denotes the number of operational risks;
- $N_i$ denotes the number of crystallisations arising from the $i^{th}$ operational risk over the specified time horizon (i.e. it is the random variable relating to the frequency of loss); and
- $X_{ij}$ denotes the operational loss arising from the $j^{th}$ loss event arising by the $i^{th}$ operational risk (i.e. it is the random variable relating to the severity of loss).

(b) Once distributions have been selected for $N_i$ and $X_{ij}$ (as per the first step – for example a Poisson or perhaps Negative Binomial for each $N_i$) random observations from those distributions are selected so as to enable the statistical sampling of the operational losses for each of the individual operational risks.

The simulations from these distributions might, for example, be generated using a method which maps random variables generated from a $U[0,1]$ distribution onto the cumulative probability functions of the fitted distributions.

The Monte Carlo method produces a simulated aggregate operational loss distribution, combining the random simulations from the $N$ and $X$ distributions for each individual risk, and summing across these risks.

We are likely to model correlations between the frequencies of the $k$ operational risks. These correlations will be reflected in the simulated aggregate operational loss distribution.

The average (mean) of all simulated aggregate losses might be used for a "best estimate" measurement, and the 99.5$^{th}$ percentile might be used to inform the setting of required operational risk capital.

A sufficiently high number of simulations (or "observations") is required so as to reduce sampling error.

(ii) Fit a Poisson distribution for frequency as this is the simplest frequency distribution to fit to the limited historical loss data.

The exposure period is five years and three observations have been made over this period giving a sample mean frequency of 0.6. Therefore, fitting a Poisson distribution to the historical loss data on internal fraud yields the following frequency distribution:

$$\text{Poisson}(\hat{\lambda} = 0.6)$$

*[The binomial distribution was also accepted.]*

(iii) The likelihood function is:

$$L(k,\ \theta) = \prod_{i=1}^{N} x_i^{k-1} . \frac{e^{\frac{-x_i}{\theta}}}{\theta^k \Gamma(k)} .$$

Taking logarithms:

$$\ell(k,\theta) = (k-1)\sum_{i=1}^{N} \ln(x_i) - \sum_{i=1}^{N} \frac{x_i}{\theta} - Nk \ln(\theta) - N \ln(\Gamma(k)) .$$

Differentiating with respect to θ gives:

$$\frac{\partial(\ell(k,\theta))}{\partial\theta} = \sum_{i=1}^{N} \frac{x_i}{\theta^2} - \frac{Nk}{\theta} .$$

Setting to zero:

$$\sum_{i=1}^{N} \frac{x_i}{\theta} = Nk .$$

Hence:

$$\hat{\theta} = \frac{\sum_{i=1}^{N} x_i}{Nk}.$$

Our estimate of $s$ to three decimal places can be derived using the historical loss data as follows:

$$s = \log((46{,}500 + 3{,}100 + 1{,}700) / 3) - (\log(46{,}500) + \log(3{,}100) + \log(1{,}700)) / 3$$

$$= \log(17{,}100) - 26.225 / 3$$

$$= 1.005$$

Using our estimate for $s$ we can calculate our estimate of $k$ to three decimal places as follows:

$$k \approx [3 - 1.005 + \sqrt{((1.005 - 3)^2 + 24 * 1.005)}] / (12 * 1.005)$$

$$= 0.605$$

Using our estimate for $k$ we can calculate our estimate of $\theta$ to three decimal places as follows:

$$\theta = ((46{,}500 + 3{,}100 + 1{,}700)/3)/0.605$$

$$= 28{,}272$$

Therefore, fitting a Gamma distribution to the historical loss data on internal fraud yields the following severity distribution:

$$\text{Gamma}(k = 0.605, \theta = 28{,}272)$$

(iv)

- The company can collect internal historical loss data using incident reporting for both actual operational losses and near misses. This should be both easy to collect and readily available.
- The data would also be directly relevant to the company.
- If there were any high frequency risks, such as credit card fraud, it may be possible to use this data directly when calibrating frequency and severity distributions.
- Such an approach provides a straightforward method for estimating the operational risk capital.
- However, for less frequent risks there will be limited internally collected historical loss data available.
- This seems to be the case for this company, which was only established five years ago and has experienced only a small number of actual losses.

- Further teething problems are to be expected since the process for the collection of historical loss data will be in its infancy.
- Under the new solvency 2 regime, regulators will be looking to companies to evidence that they have validated the assumptions to their internal capital models. The collection of historical data should be very helpful for this purpose.

Challenges include:

- the categorisation of risk, which may prove difficult if there is more than one control failure leading to the crystallisation;
- the inconsistent reporting of losses and near misses;
- the failure to report losses and near misses;
- and the fact that internal loss data is retrospective and as such does not allow for any changes to the operating environment including product mix, control environment, et al.
- Finally, it does not engage the business's experts in the process of loss estimation and hence, does not support the integration of risk and capital management.

(v) <u>External loss data</u>

- Historic losses incurred by other insurance companies may be reported into a central loss database administered by a third party such as the ABI's ORIC database (if the company is a UK life insurer).
- In addition, operational losses are sometimes reported in the press. Such information could be collected by an internal team or accessed through subscribing to a collection service provider.

<u>Scenario Loss Data</u>

- Scenario loss data can be created by bringing together experts from around the business to brainstorm how various risks may crystallise
- and the implications having regard to their control environment, insurances, indemnities, et al.

*[Answers based on two separate sources of external data were also accepted.]*

(vi) <u>External loss data</u>

The insurance company could subscribe to a consortium collecting external loss data in the short term to address gaps in their internal loss data.

However, most databases have only recently been established and hence, are subject to the same issues previously detailed in respect of internally collected historic loss data.

There are further issues as follows:

- There is an issue regarding the timeframe over which the loss data has been collected; what is an appropriate exposure measure?
- There is a related issue regarding scalability of the externally collected historical loss data; what is an appropriate scaling factor?
- There is a question of applicability; could a reported loss actually happen to our insurance company?
- The classification and granularity of the losses reported; how do we allow for any truncation of the externally collected loss data?
- The externally collected historical loss data is likely to be incomplete – e.g. other insurance companies are likely to be unwilling to record unique losses.
- The heterogeneity within the data in terms of the different features of the contributors. For example, different contributors will have different operational risk control/mitigation
- And again the data is retrospective.

Depending on the information available from the consortium, consider filtering the externally collected historical loss data for those that are applicable and then scale those that are applicable to allow for the difference in size of the contributing member and the size of our insurance company.

Then use Bayesian techniques to combine this with the insurance company's internal loss data.

Scenario loss data

- Obtaining scenario data loss for all operational risks is a significant undertaking, especially on a process by process basis.
- Therefore, many insurance companies firstly obtain self assessment data to prioritise those operational risks for which further consideration is required and to understand the cause and effect for operational risks.
- Such cause and effect analysis can feed directly into the setting of correlations.
- Scenario loss data can be collected in a number of ways, although workshop based sessions with all the relevant business experts present are very popular. These sessions need to be run sufficiently frequently so as to ensure that the scenarios are up to date, but not so often so as to risk the exercise becoming a tick-box exercise.

Issues that arise with the collection of scenario loss data include:

- the lack of statistical understanding of the participants requiring careful framing of the questions;
- gaming by some of the participants so as to paint their own department in a positive or negative light;
- and biases such as for example, hindsight bias whereby participants views are biased to those events that have recently occurred.

- Facilitation by the insurance company's central risk team should be employed so as to identify and eliminate gaming by participants.
- Sourcing estimates from all participants and then reaching a consensus can reduce the tendency for the scenario loss data to be focused on the views of the more vocal participants and help to eliminate biases.
- As before, use Bayesian techniques to combine the scenario loss data with the historical loss data.

## END OF EXAMINERS' REPORT